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THE 1980 FOLLOW-UP REPORT ON AIR QUALITY IN THE TORONTO SUBWAY SYSTEM

December 1980

Report ARB-TDA-63-80

ONTARIO MINISTRY OF THE ENVIRONMENT

ONTARIO MINISTRY OF LABOUR

TORONTO TRANSIT COMMISSION

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ONTARIO MINISTRY OF THE ENVIRONMENT
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1.0 SUMMARY

This report details the improvements in subway air quality as a result of the abatement program undertaken by the Toronto Transit Commission, in accordance with the recommendations of the Working Group on Air Quality in the Toronto Subway System[1]. These improvements reinforce the earlier conclusions of the Working Group that there are no discernible health hazards due to airborne contaminants in the Toronto Subway System.

1.1 Findings

The findings indicate a significant improvement in air quality over the four year period, 1976 to 1980, through the reduction of lead, asbestos and suspended particulate matter. In brief, the findings were:

(1) Lead level reduction of greater than 90% at both Lawrence and Bay Stations.

(2) A reduction in the concentration of chrysotile asbestos fibre greater than 5 micrometers in length.

(3) Total Suspended Particulate reduction of 60% at Lawrence Station (representing the Yonge-University-Spadina line) and 30% at Bay Station (representing the Bloor-Danforth line).

1.2 Conclusions

(1) The equipment changes recommended by the Working Group on Air Quality in the Toronto Subway System and other measures undertaken by the TTC were successful and produced significant improvements in air quality. The specific abatement objectives set forth in the March 1980 report were met.

(2) The Ontario Ministry of the Environment 24-hour ambient air criterion for lead (5 ug/m^3) has been met in both the Yonge-University-Spadina and Bloor-Danforth Sections.

(3) Asbestos levels have been reduced to the point where they would meet the Ontario Ministry of the Environment 24-hour ambient air guideline for asbestos (0.04 fibres >5 um/cc) in nearly all cases.

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1. The Report of the Working Group on Air Quality in the Toronto Subway System, Report No. 12-80 ARB-TDA March 1980, Ministry of the Environment and the Ministry of Labour.

(4) The total suspended particulate matter, which consists mostly of iron and carbon, has been greatly reduced but is still higher than the 24-hour ambient air criterion. Further reductions will be difficult even with the application of the best available technology.

(5) Follow-up occupational health tests by the Ministry of Labour have shown that monitored levels are reduced from those previously measured, confirming that exposure of TTC subway employees to air contaminants is well within established standards or guidelines. In addition, tests have shown that levels of lead in the blood of a representative group of TTC subway employees are not significantly different from those of typical urban residents.

(6) Conclusions reached in the earlier subway air quality study (reported in March 1980), which stated that there were no public or employee health hazards attributable to subway air contaminants at the levels measured to that time, are thus reinforced by the further improvements in air quality that have occurred since 1976/1977.

1.3 Recommendations

(1) The TTC should continue converting the brake shoes on 'G' cars from the Cobra W-392 model (lead-free) to the Abex 'Tiger' (lead- and asbestos-free). This change will further reduce asbestos levels on the Yonge-University-Spadina line and should also reduce lead levels somewhat. The slight increase in brake shoe particulate emissions that will accompany the change should still produce TSP levels appreciably below the levels measured in 1976/77.

(2) Follow-up monitoring to determine the effects of air quality of the above change should be carried out by the T.T.C. when the change is complete. The recommended parameters for monitoring are TSP and lead. These could be determined by several days of HiVol sampling at representative stations, since the various parameters are reproducible from day-to-day in the subway.

(3) Similarly, since none of the equipment changes will produce significant changes in TTC subway employee exposure to air contaminants, it is not necessary to carry out employee personal monitoring of subway employees for the purposes of the recommended follow-up study. Periodic routine personal monitoring according to Minsitry of Labour guidelines is, of course, still recommended.

2.0 INTRODUCTION

The report of the working group on air quality in the Toronto Subway System was released in March of 1980 and gave a detailed description of the studies and findings of air quality in the Toronto Subway System up to that date. The recommendations made at that time were:

1) Although there are no current or imminent health hazards that may be attributed to airborne contaminants in the subway system at the concentrations that have been measured, action to reduce the concentrations of lead, asbestos, and suspended particulate matter in subway air should continue. This action will improve subway air quality for both passengers and employees.

2) The abatement objectives for all contaminants should be to reduce typical levels on the Yonge-University-Spadina line to levels similar to those found currently on the Bloor-Danforth line as soon as is practicable, using the best available technology.

3) Implementation of a specific abatement program to achieve the objectives set out above should be continued by the TTC in accordance with Ministry of the Environment guidelines.

4) Air quality in the subway should be monitored regularly by the TTC at one or more sites, in co-operation with the Ministry of the Environment.

5) Progress on the continuing abatement program and monitoring should be reported at the end of 1980, and the report made public.

6) Although TTC employees are not being exposed to high levels of asbestos and lead, it is recommended that periodic personal monitoring of TTC employees, utilizing individual (personal) air quality monitoring equipment, be carried out in accordance with Ministry of Labour guidelines.

In April and May of 1980, a follow-up study was undertaken by the Ministry of Labour and the Ministry of the Environment to address recommendations 3, 4, 5 and 6.

This report presents the findings of that survey.

3.0 T.T.C. Subway Operation 1980

3.1 System Layout

A layout of the system is given in Figure 3.1. The Kipling and Kennedy stations were under construction during the survey and were opened November 1980.

3.2 Operating Characteristics

Tables 3.1 and 3.2 present the headway (time between trains), fleet arrangements and frequency of operation in effect during the survey.

3.3 Fleet Composition

The 1980 fleet consists of 494 Montreal Locomotive Works ('M') cars and Hawker-Siddeley Canada Limited ('H') cars and 134 Gloucester ('G') cars. Of these about 260 'H' cars and 134 'G' cars were in commission on the Yonge-University-Spadina Line.

FIGURE 3.1 MAP OF TTC SUBWAY SYSTEM

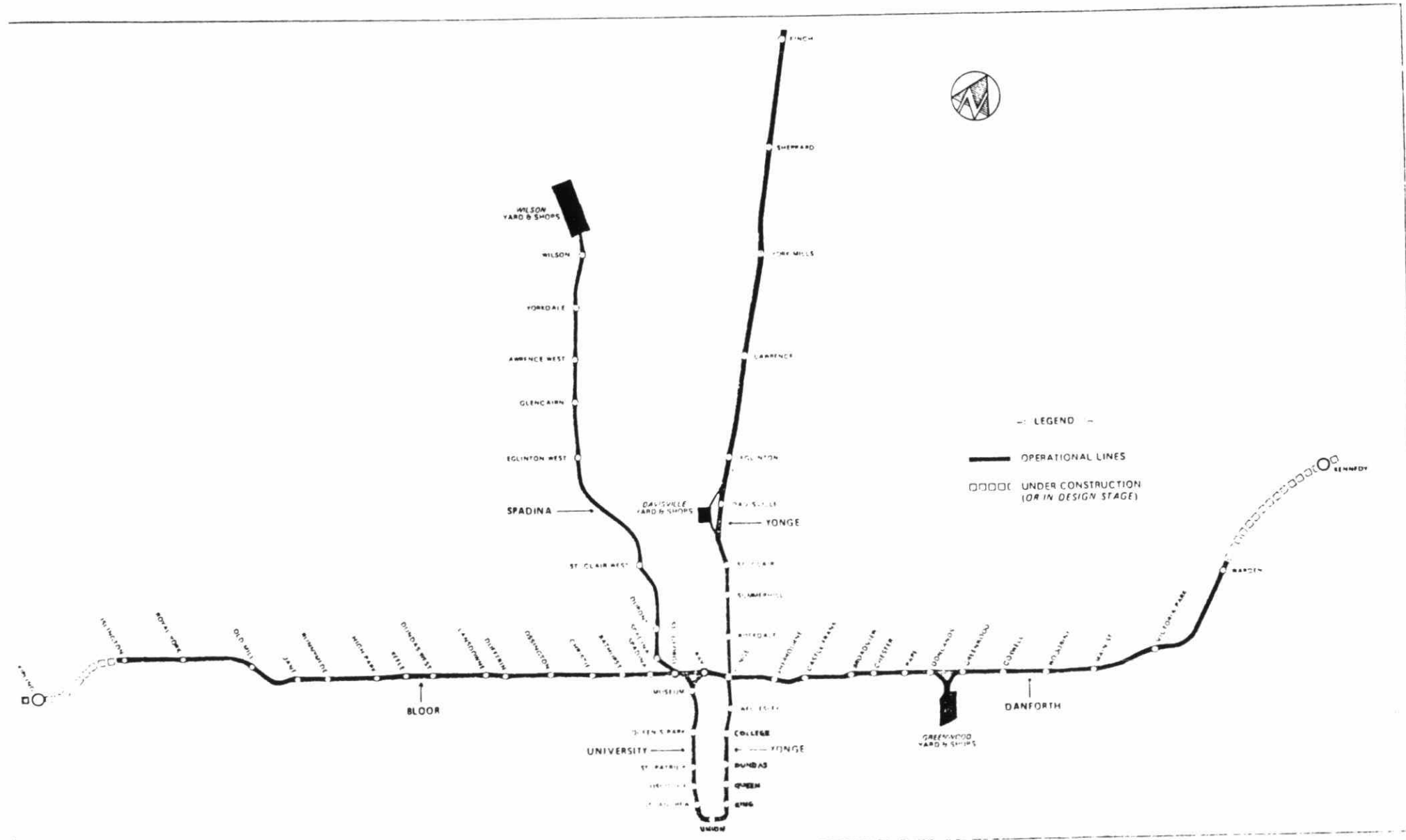


Table 3.1

SUBWAY SERVICE
April - May, 1980

Yonge-University - Spadina					Headway (min.)	Trains (#)
Daily	-	7.00 a.m.	-	9.00 a.m.	2.21	41
		9.00 a.m.	-	4.00 p.m.	3.42	29
		4.00 p.m.	-	6.00 p.m.	2.15	43
		6.00 p.m.	-	10.00 p.m.	3.42	29
		10.00 p.m.	-	2.00 a.m.	4.40	23
Saturday		7.00 a.m.	-	6.00 p.m.	3.42	29
		6.00 p.m.	-	10.00 p.m.	3.42	29
		10.00 p.m.	-	2.00 a.m.	4.40	23
Sunday		All Day			4.40	23
& Holiday		All Day			5.50	18
Bloor-Danforth						
Daily	-	7.00 a.m.	-	9.00 a.m.	2.43	29
		9.00 a.m.	-	4.00 p.m.	4.49	16
		4.00 p.m.	-	6.00 p.m.	2.43	29
		6.00 p.m.	-	10.00 p.m.	5.04	15
		10.00 p.m.	-	2.00 a.m.	5.04	15
Saturday		7.00 a.m.	-	7.30 p.m.	4.45	16
		7.30 p.m.	-	10.00 p.m.	4.45	16
		10.00 p.m.	-	2.00 a.m.	5.04	15
Sunday		All Day			5.04	15
& Holiday		All Day			5.50	13

Table 3.2

Frequency of Operation*

Weekday Median, April - May 1980

System	TIME									
	700 - 900		900 - 1600		1600 - 1800		1800 - 2200		2200 - 200	
	G	H	G	H	G	H	G	H	G	H
Danforth-Bloor	0	148.1	0	80.2	0	148.1	0	71.4	0	54.5
Yonge-University - Spadina	68.5	111.2	38.7	70.2	67.5	116.8	25.0	83.5	17.8	42.7

* Number of cars operating in one direction per hour.
M cars grouped with H cars.

4.0 1980 Environmental Test Program

4.1 Survey Logistics & Instrumentation

The 1980 survey was carried out at Queen's Park, Lawrence and Bay stations, trackside level, from April 28th to May 16th. These stations were chosen as being representative of the North-South system component and the East-West component. Asbestos, TSP and the concentrations of the elemental components of TSP, and the coefficient of haze (COH) were monitored as in the 1976 survey.

In addition, a limited survey was performed by the Ontario Research Foundation (ORF) at the Lawrence, Queen's Park and Sheppard stations on March 24, 25 and 26, 1980 for asbestos only. The asbestos sampling train in both surveys consisted of a low volume sampler connected to a standard 37 mm three piece Millipore field monitor. The collection medium was a 37 mm, 0.4 um pore size polycarbonate filter backed by a 0.8 um pore size cellulose mixed ester filter and cellulose backup pad.

A standard high volume sampler using 8" x 10" glass fibre filters was used for particulate collection. The sample collection cycle was programmed for noon to noon operation.

The COH units were located at the Bay station from May 1st to May 16th and at the Lawrence station from April 28th to May 16th.

4.2 Sample Analysis

Asbestos filters were prepared by the carbon coating replication technique and examined by electron microscopy by both ORF (March survey) and MOE* (April-May survey).

Glass fibre filters were analyzed for TSP gravimetrically.*

The trace metals cadmium, chromium, copper, iron, manganese, nickel, lead, vanadium and zinc were analyzed by plasma arc emission spectroscopy. Both total and free carbon were also analyzed.*

COH instrumentation was linked to a plotter, providing continuous recording on site.

4.3 Results

4.3.1 Asbestos

Tables 4.1 and 4.2 present the results for both the ORF and MOE *

* Analysis by the Ministry of the Environment Laboratory Services Branch.

surveys. None of the ORF samples exceeded the MOE 24 hour guideline value of 0.04 fibres/cc of asbestos greater than 5 um in length. Three of the twenty MOE subway samples marginally exceeded the guideline value. Two of these samples were taken at Queen's Park and had values of 0.05 and 0.06 fibres/cc, the third sample was taken at Lawrence station and had a concentration of 0.07 fibres/cc of chrysotile asbestos greater than 5 um in length.

Some filters were slightly contaminated with asbestos fibres less than 5 um in length but this did not affect the determination of fibres longer than 5 um.

4.3.2 Total Suspended Particulate (TSP)

TSP results for Lawrence, Queen's Park and Bay stations are given in Tables 4.3 to 4.5 and the weekday means are 646 ug/m^3, 386 ug/m^3 and 430 ug/m^3 for these stations respectively. The MOE 24 hour ambient air quality criterion for total suspended particulate matter is 120 ug/m^3.

4.3.3 Lead

Lead results for Lawrence, Queen's Park and Bay stations are given in Tables 4.3 to 4.5. None of the samples exceeded the MOE 24 hour ambient air quality criterion of 5 ug lead/m^3.

4.3.4 Other Metals

Weekday and weekend concentrations for cadmium, chromium, copper, iron, manganese, nickel, vanadium, zinc and total carbon (combined and free) are given in Table 4.6.

4.3.5 Coefficient of Haze (COH)

Coefficient of haze results averaged over six subway operation periods for Lawrence and Bay stations are presented in Tables 4.7 and 4.8.

Correlation data for TSP and COH are summarized in Tables 4.9 and 4.10. The one parameter linear regression equation for Lawrence station is TSP = 67.3 COH and for Bay station is TSP = 67.9 COH .

4.3.6 Air Quality Comparison

4.3.6.1 Danforth-Bloor Line vs Yonge-University-Spadina Line

Statistical tests* were used to determine whether the air quality was significantly different at stations on the Danforth-Bloor Line and Yonge-University-Spadina Line.

The comparison results are:

(1) Mean weekday TSP levels are significantly different between the Yonge-University-Spadina Line (Y-U-S) and the Danforth-Bloor Line (D-B).

(2) Mean weekday lead levels are significantly different between the Y-U-S Line and the D-B Line.

(3) There is no statistically significant difference in asbestos levels between the Y-U-S Line and the D-B Line, based on mean weekday concentrations of chrysotile asbestos fibres greater than 5 micrometers in length

4.3.6.2 Ambient Asbestos Levels vs Subway Asbestos Levels

There is no statistically significant difference between asbestos levels in the subway and those in ambient downtown Toronto air as measured at 880 Bay St. (see Table 4.11, for statistical comparison results).

* Total suspended particulate, lead and asbestos results were used to test the null hypothesis that the air quality (based on either TSP, Lead or Asbestos) found in the Danforth-Bloor Line is the same as that found in the Yonge-University-Spadina Line at a significance level of 0.05 using a two tail distribution. The calculation assumes a normal distribution, though this may not be the case. A comparison of the sample variance indicates that the equality of variances is not a reasonable conjecture, therefore an approximate procedure proposed by W.G. Cochran was used to test the equality of the two population means.

Table 4.1

1980 ORF/TTC AIR QUALITY SURVEY ASBESTOS ANALYSIS RESULTS

Date	Location (filter #)	Chrysotile Fibres (>5 um in length) # fibres	Chrysotile Fibres (>5 um in length) fibres/cc	Chrysotile Fibres Total # fibres	Chrysotile Fibres Total fibres/cc	Total Asbestos Fibres[1] (>5 um in length) # fibres	Total Asbestos Fibres[1] (>5 um in length) fibres/cc	Remarks
24.03.80	Queen's Park (21) trackside	1	0.005	11	0.055	1	0.005	
25.03.80	Queen's Park (37) trackside	0	< 0.007	6	0.039	0	<0.007	
26.03.80	Queen's Park (45)	0	<0.007	4	0.025	0	<0.007	
Total Samples		3	3	3	3	3	3	
Range		0-1	0-0.005	4-11	0.025-0.055	0-1	0-0.005	
Mean		0	0.002	7	0.040	0	0.002	
24.03.80	Lawrence (25) trackside	1	0.007	12	0.086	1	0.007	
25.03.80	Lawrence (39) trackside	0	< 0.008	20	0.14	0	<0.008	
26.03.80	Lawrence (47) trackside	0	< 0.008	9	0.064	0	<0.008	
Total Samples		3	3	3	3	3	3	
Range		0-1	0-0.007	9-20	0.064-0.14	0-1	0-0.007	
Mean		0	0.002	14	0.097	0	0.002	

1. Sum of Chrysotile and Amphibole Fibres
MOE guideline for asbestos, 0.04 fibres greater than 5 um in length/cc

Table 4.1 Continued

1980 ORF/TTC AIR QUALITY SURVEY ASBESTOS ANALYSIS RESULTS

Date	Location (filter #)	Chrysotile Fibres (>5 um in length) # fibres	Chrysotile Fibres (>5 um in length) fibres/cc	Chrysotile Fibres Total # fibres	Chrysotile Fibres Total fibres/cc	Total Asbestos Fibres[1] (>5 um in length) # fibres	Total Asbestos Fibres[1] (>5 um in length) fibres/cc	Remarks
24.03.80	Lawrence (23) bus level	0	< 0.006	3	0.016	0	<0.006	
25.03.80	Lawrence (41) bus level	0	<0.007	2	0.013	0	< 0.007	
26.03.80	Lawrence (49) bus level	0	<0.007	3	0.018	0	< 0.007	
Total Samples		3	3	3	3	3	3	
Range		0	0	2-3	0.013-0.018	0	0	
Mean		0	0	3	0.016	0	0	
24.03.80	Sheppard (27) trackside	0	<0.008	6	0.046	0	< 0.008	
25.03.80	Sheppard (43) trackside	0	<0.009	9	0.072	0	< 0.009	
26.03.80	Sheppard (51) trackside	2	0.015	15	0.11	2	0.015	
Total Samples		3	3	3	3	3	3	
Range		0-2	0-0.015	6-15	0.046-0.11	0-2	0-0.015	
Mean		1	0.005	10	0.076	1	0.005	

1. Sum of Chrysotile and Amphibole Fibres
MOE guideline for asbestos, 0.04 fibres greater than 5 um in length/ml

Table 4.2

1980 TTC/MOE AIR QUALITY SURVEY ASBESTOS ANALYSIS RESULTS

Date	Location (filter #)	Chrysotile Fibres (>5 um in length) # fibres	Chrysotile Fibres (>5 um in length) fibres/cc	Chrysotile Fibres Total # fibres	Chrysotile Fibres Total fibres/cc	Total Mineral Fibres[3] (>5 um in length) # fibres	Total Mineral Fibres[3] (>5 um in length) fibres/cc	Remarks
03.05.80	Lawrence (15)	0	BDL	28	0.29	1	0.01	
04.05.80	Lawrence (16)	0	BDL	16	0.18	0	BDL	
05.05.80	Lawrence (-)	-	-	-	-	-	-	
06.05.80	Lawrence (18)	0	BDL	42	0.55	0	BDL	1
07.05.80	Lawrence (17)	4	0.07	25	0.44	4	0.07	
08.05.80	Lawrence (21)	1	0.01	28	0.34	1	0.01	
09.05.80	Lawrence (23)	0	BDL	26	0.53	0	BDL	1
Total Samples		6	6	6	6	6	6	
Range		0-4	0-0.07	16-42	0.18-0.55	0-4	0-0.07	
Mean		1	0.01	28	0.39	1	0.015	
03.05.80	Bay (13)	0	BDL	18	0.16	1	0.009	
04.05.80	Bay (14)	0	BDL	23	0.30	1	0.013	
05.05.80	Bay (12)	0	BDL	33	0.61	0	BDL	
06.05.80	Bay (17)	0	BDL	35	0.37	0	BDL	1
07.05.80	Bay (21)	0	BDL	13	0.12	0	BDL	
08.05.80	Bay (16)	0	BDL	25	0.24	0	BDL	
09.05.80	Bay (10)	0	BDL	9	0.12	0	BDL	
Total Samples		7	7	7	7	7	7	
Range		0-0	0-0	5-35	0.12-0.61	0-1	0-0.013	
Mean		0	0	22	0.27	0	0.003	
03.05.80	Queen's Park (23)	0	BDL	22	0.23	0	BDL	1
04.05.80	Queen's Park (14)	2	0.02	19	0.20	2	0.02	
05.05.80	Queen's Park (19)	0	BDL	17	0.15	0	BDL	
06.05.80	Queen's Park (9)	0	0	19	0.21	0	0	
07.05.80	Queen's Park (17)	5	0.05	9	0.09	5	0.05	
08.05.80	Queen's Park (21)	6	0.06	47	0.47	6	0.06	1
09.05.80	Queen's Park (20)	2	0.02	32	0.32	3	0.03	
Total Samples		7	7	7	7	7	7	
Range		0-6	0-0.06	9-47	0.09-0.47	0-6	0-0.06	
Mean		2	0.021	24	0.24	2	0.023	

Table 4.2 Continued

Date	Location (filter #)	Chrysotile Fibres (>5 um in length) # fibres	Chrysotile Fibres (>5 um in length) fibres/cc	Chrysotile Fibres Total # fibres	Chrysotile Fibres Total fibres/cc	Total Mineral Fibres[3] (>5 um in length) # fibres	Total Mineral Fibres[3] (>5 um in length) fibres/cc	Remarks
03.05.80	Ambient (5)[2]	0	BDL	13	0.02	1	0.001	
04.05.80	----	-	-	-	-	-	-	
05.05.80	Ambient (1)	2	0.001	22	0.01	2	0.001	
06.05.80	Ambient (7)	0	BDL	14	0.02	1	0.001	
07.05.80	Ambient (2)	0	BDL	5	0.01	0	BDL	
08.05.80	Ambient (3)	0	BDL	26	0.04	0	BDL	
09.05.80	Ambient (6)	0	BDL	5	0.01	0	BDL	
Total Samples		6	6	6	6	6	6	
Range		0-2	0-0.001	5-26	0.01-0.04	0-2	0-0.001	
Mean		0	0	14	0.02	1	0.0005	
Blank	Lawrence (B1-1)	0	NA	24	NA			
Blank	Lawrence (B1-2)	0	NA	37	NA			
Blank	Bay (B1-1)	1	NA	24	NA			
Blank	Bay (B1-2)	1	NA	24	NA			
Blank	Bay (B1-3)	0	NA	7	NA			
Blank	Queen's Park (B1-1)	0	NA	18	NA			
Blank	Queen's Park (B1-1)	0	NA	14	NA			
Blank	Ambient (B1-1)	1	NA	39	NA			
Total Samples		8		8				
Range		0-1	NA	7-39	NA			
Mean		0	NA	23	NA			

1 Bundle Detected
2 Ambient Sampling at Bay & Grosvenor, Toronto
3 Sum of Chrysotile, and mineral fibres with an aspect ratio of 3:1 or greater
BDL Below Detection Limit. Limits vary from <0.009 fibres/cc to <0.019 fibres/cc depending on air volume sampled
- Invalid Sample
NA Not Applicable

Table 4.3

HI-VOL RESULTS FOR LAWRENCE STATION

EXPOSURE DATE 1980	T.S.P. ug/m^3	% Fe in T.S.P.	% FREE C in T.S.P.	Pb ug/m^3
April 28 (Mon)	469	45.2	9.6	1.9
April 29 (Tues)	520	43.9	8.7	2.1
April 30 (Wed)	578	41.8	8.2	2.3
May 1 (Thurs)	550	39.0	9.1	2.0
May 2 (Fri)	510	43.0	8.5	2.2
May 3 (Sat)	471	41.0	10.0	2.3
May 4 (Sun)	640	42.3	9.8	3.1
May 5 (Mon)	798	40.9	8.1	3.2
May 6 (Tues)	792	44.3	8.2	3.2
May 7 (Wed)	726	46.2	9.8	3.2
May 8 (Thurs)	727	44.4	9.9	2.7
May 9 (Fri)	708	44.1	9.2	3.1
May 10 (Sat)	477	43.6	11.3	2.4
May 11 (Sun)	442	44.3	12.6	1.9
May 12 (Mon)	668	45.9	9.5	2.6
May 13 (Tues)	601	43.3	9.6	2.1
May 14 (Wed)	671	44.8	8.9	2.4
May 15 (Thurs)	726	46.6	8.3	2.5
Weekday Mean	646	43.9	8.9	2.5

Table 4.4

HI-VOL RESULTS FOR QUEEN'S PARK STATION

EXPOSURE DATE 1980	T.S.P. ug/m^3	% Fe in T.S.P.	% FREE C in T.S.P.	Pb ug/m^3
April 28 (Mon)	303	42.4	7.5	1.2
April 29 (Tues)	313	39.8	5.6	1.5
April 30 (Wed)	406	37.3	6.5	1.8
May 1 (Thurs)	404	36.8	6.3	2.0
May 2 (Fri)	357	39.4	6.4	2.0
May 3 (Sat)	215	35.6	6.1	1.6
May 4 (Sun)	321	40.1	8.1	1.8
May 5 (Mon)	471	36.1	6.5	2.1
May 6 (Tues)	434	41.9	7.4	2.0
May 7 (Wed)	438	42.4	6.3	2.2
May 8 (Thurs)	419	43.6	7.2	2.3
May 9 (Fri)	361	42.1	6.4	2.0
May 10 (Sat)	180	37.9	6.6	1.1
May 11 (Sun)	299	41.0	8.5	1.4
May 12 (Mon)	382	43.4	8.3	1.8
May 13 (Tues)	366	40.4	7.5	1.8
May 14 (Wed)	358	29.4	6.8	1.2
May 15 (Thurs)	388	33.5	6.4	1.3
Weekday Mean	385.7	39.2	6.8	1.8

Table 4.5

HI-VOL RESULTS FOR BAY STATION

EXPOSURE DATE 1980	T.S.P. ug/m^3	% Fe in T.S.P.	% FREE C in T.S.P.	Pb ug/m^3
April 28 (Mon)	396	49.0	4.1	0.8
April 29 (Tues)	453	47.5	4.8	1.2
April 30 (Wed)	458	42.8	3.9	1.3
May 1 (Thurs)	493	45.9	4.0	1.3
May 2 (Fri)	430	44.2	3.9	1.2
May 3 (Sat)	260	42.3	3.5	0.7
May 4 (Sun)	354	46.3	4.0	1.0
May 5 (Mon)	439	44.8	4.2	1.1
May 6 (Tues)	460	45.8	3.9	1.2
May 7 (Wed)	417	45.9	3.5	1.0
May 8 (Thurs)	358	47.9	3.8	0.9
May 9 (Fri)	369	47.5	3.9	1.0
May 10 (Sat.)	294	44.6	5.3	0.9
May 11 (Sun)	299	44.2	4.4	0.8
May 12 (Mon)	450	48.2	4.3	1.4
May 13 (Tues)	437	44.0	3.8	1.1
May 14 (Wed)	400	45.0	4.4	1.1
May 15 (Thurs)	454	43.6	4.1	1.2
Weekday Mean	430	45.7	4.1	1.1

Table 4.6

1980 TTC AIR QUALITY TRACE METAL RESULTS

(all concentrations in micrograms per cubic meter, ug/m^3)

STATION WKDAY OR WKEND	T.S.P.	Total Carbon*	Free Carbon*	Cd	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
LAWRENCE												
Wkday												
Mean	646	147	57.8	0.017	0.513	4.14	283	2.47	0.220	2.54	0.037	1.09
St. Dev	108	25.6	9.94	0.006	0.119	0.680	51.6	0.413	0.048	0.479	0.012	0.197
Range	(469 -798)	(107 -177)	(43.3 -72.2)	(0.007 -0.029)	(0.334 -0.651)	(3.14 -5.03)	(211 -351)	(1.86 -3.02)	(0.135 -0.282)	(1.95 -3.25)	(0.015 -0.056)	(0.779 -1.354)
# samples	14											
Wkend												
Mean	508	126	54.9	0.0158	0.357	4.47	217	1.87	0.166	2.44	0.033	0.717
St. Dev.	89.6	21.3	6.37	0.004	0.0364	0.273	36.4	0.294	0.035	0.514	0.011	0.095
Range	(442 -640)	(111 -158)	(47.0 -62.5)	(0.013 -0.021)	(0.322 -0.407)	(4.18 -4.83)	(194 -271)	(1.71 -2.31)	(0.131 -0.214)	(1.86 -3.11)	(0.021 -0.048)	(0.606 -0.807)
# Samples	4											
QUEEN's PARK												
Wkday												
Mean	386	84.0	26.2	0.0071	0.428	1.06	151	1.29	0.125	1.79	0.026	0.681
St. Dev.	47.2	13.5	4.1	0.0028	0.094	0.163	24.1	0.192	0.025	0.366	0.012	0.112
Range	(303 -471)	(58.2 -100)	(14.5 -32.1)	(0.005 -0.012)	(0.291 -0.569)	(0.769 -1.28)	(106 -186)	(0.915 -1.56)	(0.080 -0.162)	(1.15 -2.31)	(0.000 -0.048)	(0.442 -0.857)
# Samples	14											
Wkend												
Mean	254	60.0	21.1	0.006	0.195	0.986	99.0	0.841	0.074	1.48	0.022	0.379
St. Dev.	67.1	18.1	7.9	0	0.073	0.232	31.0	0.289	0.021	0.307	0.005	0.135
Range	(180 -321)	(39.5 -74.0)	(11.9 -25.9)	(0.006 -0.006)	(0.109 -0.275)	(0.754 -1.23)	(68.3 -129)	(0.523 -1.09)	(0.052 -0.095)	(1.10 -1.83)	(0.017 -0.028)	(0.244 -0.616)
# Samples	3											

* Note: total carbon is the sum of the free and combined carbon. Free carbon is the elemental carbon present in an uncombined state.

Table 4.6 Continued

Page 2

STATION WKDAY OR WKEND	T.S.P.	Total Carbon*	Free Carbon*	Cd	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
BAY												
Wkday												
Mean	430	81.4	17.4	0.006	0.211	1.558	197	1.60	0.158	1.14	0.028	0.530
St. Dev.	37.6	9.38	2.27	0.002	0.052	0.136	15.9	0.321	0.025	0.162	6.37	0.060
Range	(358 -493)	(65.3 -95.5)	(14.5 -19.9)	(0.000 -0.012)	(0.106 -0.292)	(1.40 -1.82)	(172 -226)	(1.511 -1.95)	(0.131 -0.190)	(0.795 -1.33)	(0.018 -0.037)	(0.429 -0.646)
# Samples	14											
Wkend												
Mean	302	59.6	13.0	0.004	0.138	1.50	134	1.16	0.112	0.881	0.198	0.362
St. Dev.	38.9	5.362	2.83	0.003	0.034	0.317	22.1	0.190	0.015	0.123	0.363	0.049
Range	(260 -354)	(58.8 -66.3)	(9.0 -15.5)	(0.000 -0.006)	(0.105 -0.167)	(1.12 -1.89)	(110 -164)	(0.966 -1.42)	(0.099 -0.131)	(0.741 -1.02)	(0.000 -0.031)	(0.327 -0.434)
# Samples	4											

* Note: total carbon is the sum of the free and combined carbon. Free carbon is the elemental carbon present in an uncombined state.

Table 4.7

1980 Coefficient of Haze Results: Bay Station

Date	AVERAGE C.O.H. per 1,000 linear feet					
	AM RUSH 7-9 am	DAY 9-4 pm	PM RUSH 4-6 pm	EAR.EVE 6-10 pm	LATE EVE 10-2 pm	EAR.MORN 2-7 am
May 1st (Thurs)	NA*	NA	10.0	8.2	5.8	NA
May 2nd (Fri)	9.9	9.5	9.8	7.0	6.3	3.6
May 5th (Mon)	9.0	8.0	9.1	6.9	5.0	3.1
May 6th (Tues)	8.2	7.1	11.9	10.2	7.4	2.9
May 7th (Wed)	12.2	8.7	10.4	7.9	6.7	5.7
May 8th (Thurs)	NA	9.5	10.2	6.2	5.4	4.0
May 9th (Fri)	10.7	9.1	10.5	8.1	6.9	3.5
May 12th (Mon)	11.7	9.3	10.7	8.6	6.4	4.5
May 13th (Tues)	9.6	8.9	11.0	8.9	6.8	5.1
May 14th (Wed)	8.9	8.6	9.7	7.2	5.8	3.1
May 15th (Thurs)	9.1	7.9	10.3	7.4	6.4	4.3
May 16th (Fri)	10.5	10.6	11.6	9.7	7.7	3.8
May 20th (Tues)	10.2	8.7	11.0	8.6	6.8	2.9
May 21st (Wed)	9.5	10.1	11.7	9.3	7.5	5.3
May 22nd (Thurs)	10.4	10.3	NA	NA	NA	3.9

* NA - Not Available

Table 4.8

1980 Coefficient of Haze Results: Lawrence Station

Date	AVERAGE C.O.H. per 1,000 linear feet					
	AM RUSH 7-9 am	DAY 9-4 pm	PM RUSH 4-6 pm	EAR.EVE 6-10 pm	LATE EVE 10-2 pm	EAR.MORN 2-7 am
Apr. 28th (Mon)	NA*	NA	11.7	8.4	8.3	NA
Apr. 29th (Tues)	10.9	9.3	12.9	10.0	9.0	2.5
Apr. 30th (Wed)	12.1	11.2	NA	NA	NA	3.0
May 1st (Thurs)	NA	9.3	NA	NA	NA	NA
May 2nd (Fri)	NA	NA	NA	NA	NA	NA
May 5th (Mon)	NA	NA	15.8	13.6	NA	NA
May 6th (Tues)	NA	12.2	NA	NA	NA	NA
May 12th (Mon)	10.3	9.5	13.5	11.6	9.8	3.2
May 13th (Tues)	11.8	11.3	12.1	12.1	9.0	3.8
May 14th (Wed)	10.9	9.8	12.4	10.6	9.7	3.2
May 15th (Thurs)	11.5	11.1	13.8	12.5	10.4	4.5
May 16th (Fri)	11.3	12.7	13.7	14.3	11.6	3.7
May 20 (Tues)	14.5	10.3	12.7	12.6	9.2	2.7
May 21st (Wed)	11.0	10.9	14.9	11.7	10.0	5.4
May 22nd (Thurs)	11.4	NA	NA	NA	NA	4.5

* NA - Not Available

Table 4.9

1980 TSP vs COH RELATIONSHIP: LAWRENCE STATION

Date (1980)	Time Period	Avg. COH Over Sampling Period	TSP_3 (ug/m^3)
Apr. 28 Apr. 29	1430 1155	7.7	469
Apr. 29 Apr. 30	1200 1200	8.8	520
May 10 May 11	1200 1130	5.8	477
May 11 May 12	1135 1215	6.8	442
May 12 May 13	1215 1130	9.7	668
May 13 May 14	1155 1245	9.4	601
May 14 May 15	1250 1140	9.6	671
May 15 May 16	1145 1155	10.0	726

TSP = 67.3 COH

Table 4.10

1980 TSP vs COH RELATIONSHIP: BAY STATION

Date (1980)	Time Period	Avg. COH Over Sampling Period	TSP_3 (ug/m^3)
May 2 May 3	1235 1220	6.3	430
May 3 May 4	1225 1150	3.7	260
May 4 May 5	1200 1200	5.6	354
May 5 May 6	1205 1045	6.4	439
May 6 May 7	1050 1150	8.3	460
May 7 May 8	1155 0400	7.5	417
May 8 May 9	1255 1200	7.0	358
May 9 May 10	1205	8.0	369
May 10 May 11	1230 1200	5.7	294
May 11 May 12	1205 1130	6.0	299
May 12 May 13	1135 1235	7.8	450
May 13 May 14	1240 1130	7.4	437
May 14 May 15	1135 1205	7.0	400
May 15 May 16	1210 1225	7.5	454

TSP = 67.9 COH

Table 4.11

Air Quality Statistical Comparison

	Bay vs Lawrence	Bay vs Queen's Park	Ambient vs Bay	Ambient vs Lawrence	Ambient vs Queen's Park
TSP					
d	7.10	2.73	-	-	-
$d_{0.05}$	2.16	2.16	-	-	-
LEAD					
d	10.4	6.03	-	-	-
$d_{0.05}$	2.16	2.16	-	-	-
ASBESTOS					
d	1.14	2.22	1.02	1.12	2.20
$d_{0.05}$	2.57	2.45	2.57	2.57	2.45

If $d_{0.05}$ is less than d then there is a statistically significant difference between the two data sets.

5.0 1980 MOL/TTC OCCUPATIONAL HEALTH SUVERY

5.1 Survey Logistics and Instrumentation

The 1980 Occupational Health Survey was carried out onboard trains at Pape Station for the Danforth-Bloor Line and at Lawrence Station for the Yonge-University-Spadina Line on May 5th and 6th, 1980. Total fibres, lead, copper and manganese were monitored. The samples were taken on 0.8 um pore size, cellulose acetate filters. Personnel samplers were used at a flow rate of 2.0 l/min. In addition to air monitoring, blood samples were taken from thirty-one TTC employees. These samples were analysed for lead levels at the Ministry of Labour Occupational Health Laboratory.

5.2 Sample Analysis

Total fibre analysis involved fibrous particle counting by optical phase-contrast microscopy. A fibre is defined as any observed particle with a length to width ratio of 3:1 or greater and a length greater than 5 um. It should be noted that this procedure does not differentiate between non-asbestos and asbestos fibres, hence the results are expressed as total fibres.

Air samples for lead, copper and manganese were measured by atomic absorption spectroscopy. Blood lead levels were analyzed by Delves cup-atomic absorption spectroscopy.

5.3 Results

5.3.1 Total Fibre (Air)

The sampling results for total fibres are presented in Table 5.1 for Pape and Lawrence Stations. Total fibre concentrations greater than 5 um in length were well below the 2 fibre/cc Ontario Ministry of Labour guideline for chrysotile asbestos and would also be below the proposed regulation of 1 fibre/cc of chrysotile greater than 5 um in length. These levels are also well below the proposed time weighted average exposure of 0.5 fibres greater than 5 um in length/cc for amosite and 0.2 fibres greater than 5 um in length/cc for crocidolite.

5.3.2 Lead (Air & Blood)

Table 5.2 presents the lead air levels at the Pape and Lawrence Stations. All values are below the present threshold limit value and proposed time weighted average exposure of 0.15 mg/m^3 of lead in air. The blood lead results are reported in Table 5.3.

5.3.3 Other Trace Metals (Air)

The exposure values found for manganese and copper are given in Tables 5.4 and 5.5. The values are all well below the respective threshold limit values, 1.0 mg/m^3 for copper (dust) and 5.0 mg/m^3 for manganese. In the case of manganese, all results are less than the lower limit of detection. In the case of copper, some was detected but the levels were all quite low.

Table 5.1

1980 TTC/MOL TOTAL FIBRE RESULTS

Yonge-University-Spadina Line-Lawrence Station - May 6, 1980

SAMPLE IDENTIFICATION	OCCUPATION	TOTAL FIBRES GREATER THAN 5 MICROMETERS IN LENGTH PER CC OF AIR
8	Ticket Collector	< 0.03*
7	Janitor	< 0.03
12	Trackman	< 0.03
9	Driver/Guard	< 0.03
10	Driver/Guard	< 0.03
11	Passenger	< 0.03
	Number Samples	6
	Range	< 0.03
	Mean	< 0.03

Bloor-Danforth Line-Pape Station - May 6, 1980

SAMPLE IDENTIFICATION	OCCUPATION	TOTAL FIBRES GREATER THAN 5 MICROMETERS IN LENGTH PER CC OF AIR
28	Ticket Collector	< 0.03*
29	Janitor	< 0.03
30	Trackman	< 0.03
31	Driver/Guard	< 0.03
32	Driver/Guard	< 0.03
33	Passenger	< 0.03
	Number Samples	6
	Range	< 0.03
	Mean	< 0.03

* 0.03 f/cc is the lower limit of statistical reliability

The Ontario Ministry of Labour Guideline for chrysotile asbestos is 2 fibres greater than 5 um in length, per cc of air

Table 5.2

1980 TTC/MOL LEAD RESULTS

Yonge-University-Spadina Line-LawrenceStation - May 5, 1980

SAMPLE IDENTIFICATION	OCCUPATION	LEAD CONCENTRATION MG/M^3 OF AIR
1	Ticket Collector	< 0.01
2	Janitor	< 0.01
3	Trackman	< 0.01
4	Driver/Guard	< 0.01
5	Driver/Guard	< 0.01
6	Passenger	< 0.01
	Number Samples	6
	Range	< 0.01
	Mean	< 0.01

Bloor-Danforth Line-Pape Station

SAMPLE IDENTIFICATION	OCCUPATION	LEAD CONCENTRATION MG/M^3 OF AIR
21	Ticket Collector	< 0.01
22	Janitor	< 0.01
23	Trackman	< 0.01
24	Driver/Guard	< 0.01
25	Driver/Guard	< 0.01
26	Passenger	< 0.01
	Number Samples	6
	Range	< 0.01
	Mean	< 0.01

The threshold limit value for Lead is 0.15 mg/m^3

Table 5.3

1980 Occupational Health Blood Lead Results

Date	Blood Levels mg/L
June 4, 1980	min. 0.13
5 samples	max. 0.20
	mean 0.16
June 13, 1980	min. 0.09
26 samples	max. 0.22
	mean 0.14

Table 5.4

1980 TTC/MOL Manganese Results

Yonge-University-Spadina Line-Lawrence Station - May 5, 1980

SAMPLE IDENTIFICATION	OCCUPATION	MANGANESE CONCENTRATION MG/M^3 OF AIR
2	Ticket Collector	< 0.01
1	Janitor	< 0.01
3	Trackman	< 0.01
4	Driver/Guard	< 0.01
6	Driver/Guard	< 0.01
5	Passenger	< 0.01
	Number Samples	6
	Range	< 0.01
	Mean	< 0.01

Bloor-Danforth Line-Pape Station - May 5, 1980

SAMPLE IDENTIFICATION	OCCUPATION	MANGANESE CONCENTRATION MG/M^3 OF AIR
21	Ticket Collector	< 0.01
22	Janitor	< 0.01
23	Trackman	< 0.01
24	Driver/Guard	< 0.01
25	Driver/Guard	< 0.01
26	Passenger	< 0.01
	Number	6
	Range	< 0.01
	Mean	< 0.01

The threshold limit value for manganese is 5 mg/m^3. This is a ceiling value.

Table 5.5

1980 TTC/MOL COPPER RESULTS

Yonge-University-Spadina Line-Lawrence Staion - May 5, 1980

SAMPLE IDENTIFICATION	OCCUPATION	COPPER CONCENTRATION MG/M^3 OF AIR
2	Ticket Collector	0.01
1	Janitor	< 0.01
6	Trackman	0.03
3	Driver/Guard	< 0.01
4	Driver/Guard	< 0.01
5	Passenger	< 0.01
	Number	6
	Range	< 0.01-0.03
	Mean	0.01

Bloor-Danforth Line-Pape Station - May 5, 1980

SAMPLE IDENTIFICATION	OCCUPATION	COPPER CONCENTRATION MG/M^3 OF AIR
21	Ticket Collector	< 0.01
22	Janitor	< 0.01
23	Trackman	< 0.01
24	Driver/Guard	< 0.01
25	Driver/Guard	< 0.01
26	Passenger	< 0.01
	Number Samples	6
	Range	< 0.01
	Mean	< 0.01

The threshold limit value for copper (dust) is 1 mg/m^3

6.0 Comparison of 1976/77 Findings to 1980 Findings MOE/TTC Environmental Test Program

6.1 Asbestos

The 1980 survey showed lower concentrations of chrysotile fibre greater than 5 um in length than those found in 1976. Table 6.1 presents the 1976 data. At Lawrence station the chrysotile fibres greater than 5 um in length ranged between 0 -0.3 fibres/cc with a mean of 0.10 fibre/cc, the 1980 figures at this site ranged from 0 - 0.07 with a mean of 0.01 fibres/cc. The 1976 data for Queen's Park ranged from 0 - 0.2 fibres/cc, with a mean of 0.07 fibres/cc, 1980 data for that location ranged from 0 -0.06 and had a mean of 0.02. The comparison between the 1976 and 1980 concentration means are shown in Figure 6.1.

6.2 TSP

Figure 6.2 depicts the mean weekday TSP levels for both the 1976 and 1980 survey. TSP reductions from 1976 to 1980 were about 60% for Lawrence station and 30% for Bay station. At Lawrence station the mean weekday TSP values were 646 ug/m^3 in 1980 and 1635 ug/m^3 in 1976. At Bay station the values were 386 ug/m^3 in 1980 and 624 ug/m^3 in 1976.

6.3 Lead

Figure 6.3 depicts the mean weekday lead levels for the 1976 and 1980 surveys. A lead level reduction of 95% for Lawrence station and 92% for Bay was found. At Lawrence station the mean weekday lead values were 2.5 ug/m^3 in 1980 and 55.8 ug/m^3 in 1976. At Bay station the values were 1.1 ug/m^3 in 1980 and 15.9 ug/m^3 in 1976.

6.4 Other Metals

Figures 6.4 and 6.5 present 1980 vs 1976 weekday mean values for Iron and Free Carbon. Reductions are similar in magnitude to that of TSP. Comparisons could not be drawn for other metals because of limited data from the 1976 study.

6.5 Coefficient of Haze

The graphs in Figures 6.6 and 6.7 present the linear regression equations for TSP and COH for Lawrence and Bay stations. Changes probably represent a change in composition of particulate with an accompanying change in optical properties. Highest COH values were for the evening rush hour. In 1980, at Bay station, the mean evening rush hour value was 10.6, while in 1976 the mean was 10.2. At Lawrence the 1980 figure was 13.4 C.O.H. per 1,000 linear feet, while the 1976 figure was 16.3.

Table 6.1

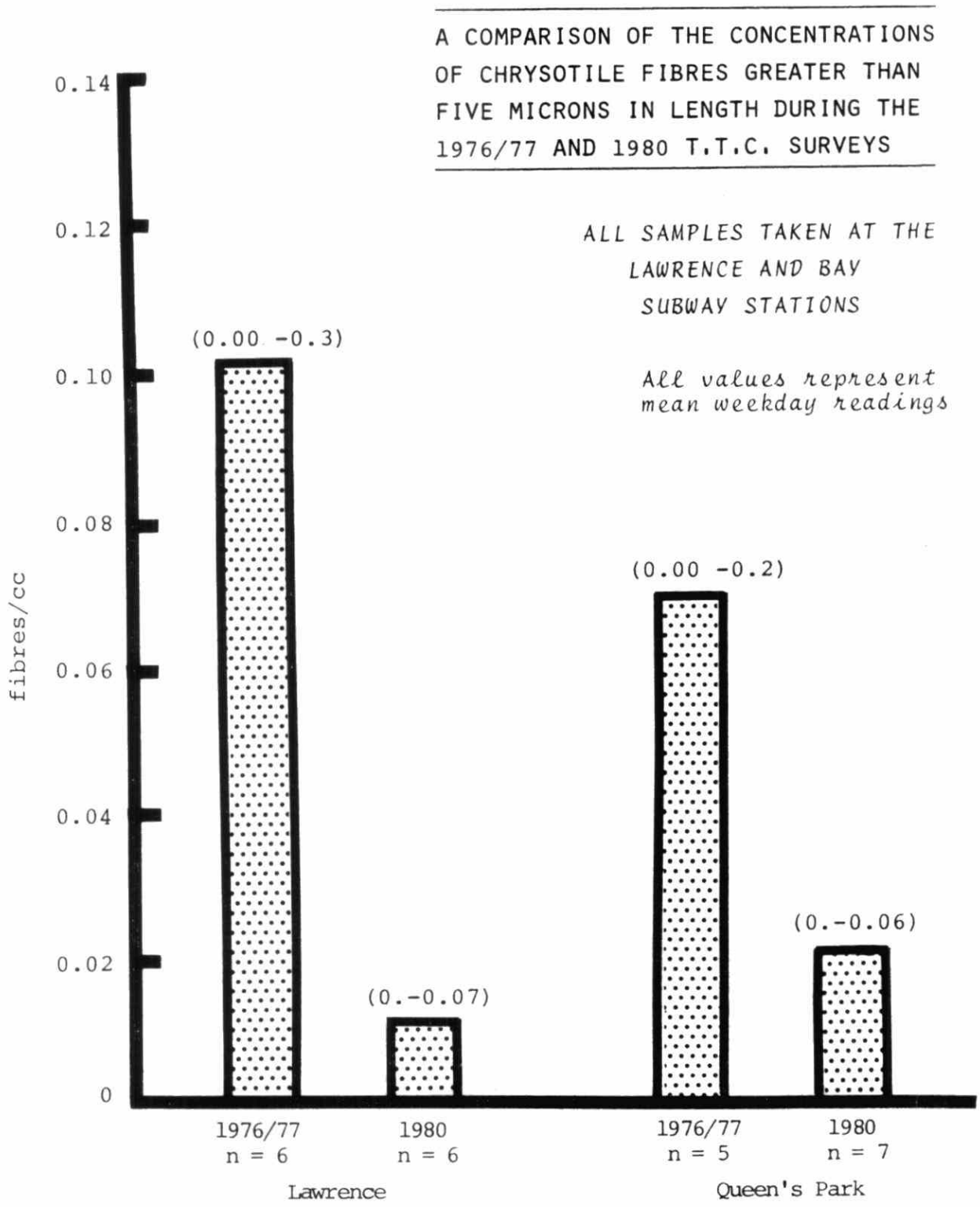
1976 MOE/TTC AIR QUALITY SURVEY ASBESTOS ANALYSIS RESULTS

Date	Location (filter #)	Chrysotile Fibres (>5 um in length) # fibres	Chrysotile Fibres (>5 um in length) fibres/cc	Chrysotile Fibres Total # fibres	Chrysotile Fibres Total fibres/cc	Total Asbestos Fibres[1] (> 5 um in length) # fibres	Total Asbestos Fibres[1] (> 5 um in length) fibres/cc	Remarks
19.10.76	Lawrence[2] (27)	NA*	0.3	NA	2.0	NA	NA	
19.10.76	Lawrence (35)	NA	0.15	NA	0.5	NA	NA	
20.10.76	Lawrence (41)	NA	0.07	NA	0.8	NA	NA	
20.10.76	Lawrence (45)	NA	< 0.005	NA	0.09	NA	NA	
20.10.76	Lawrence (51)	NA	< 0.06	NA	0.4	NA	NA	
21.10.76	Lawrence (61)	NA	< 0.01	NA	1.3	NA	NA	
Total Samples			6		6			
Range			< 0.00 -0.3		0.09-2.0			
Mean			0.1		0.85			
19.10.76	Queen's Park[2] (31)	NA	0.03	NA	1.3	NA	NA	
19.10.76	Queen's Park (33)	NA	0.20	NA	1.5	NA	NA	
20.10.76	Queen's Park (48)	NA	< 0.06	NA	0.3	NA	NA	
20.10.76	Queen's Park (56)	NA	0.07	NA	0.5	NA	NA	
21.10.76	Queen's Park (62)	NA	0.005	NA	0.02	NA	NA	
Total Samples			5		5			
Range			0.00 -0.2		0.02-1.5			
Mean			0.07		0.72			

1. Sum of Chrysotile and other Mineral Fibres
2. All Sampling trackside

* NA - not available

Figure 6.1



n = number of samples

$(X_{Low} - X_{High})$ = range of sample in fibres/cc

Figure 6.2

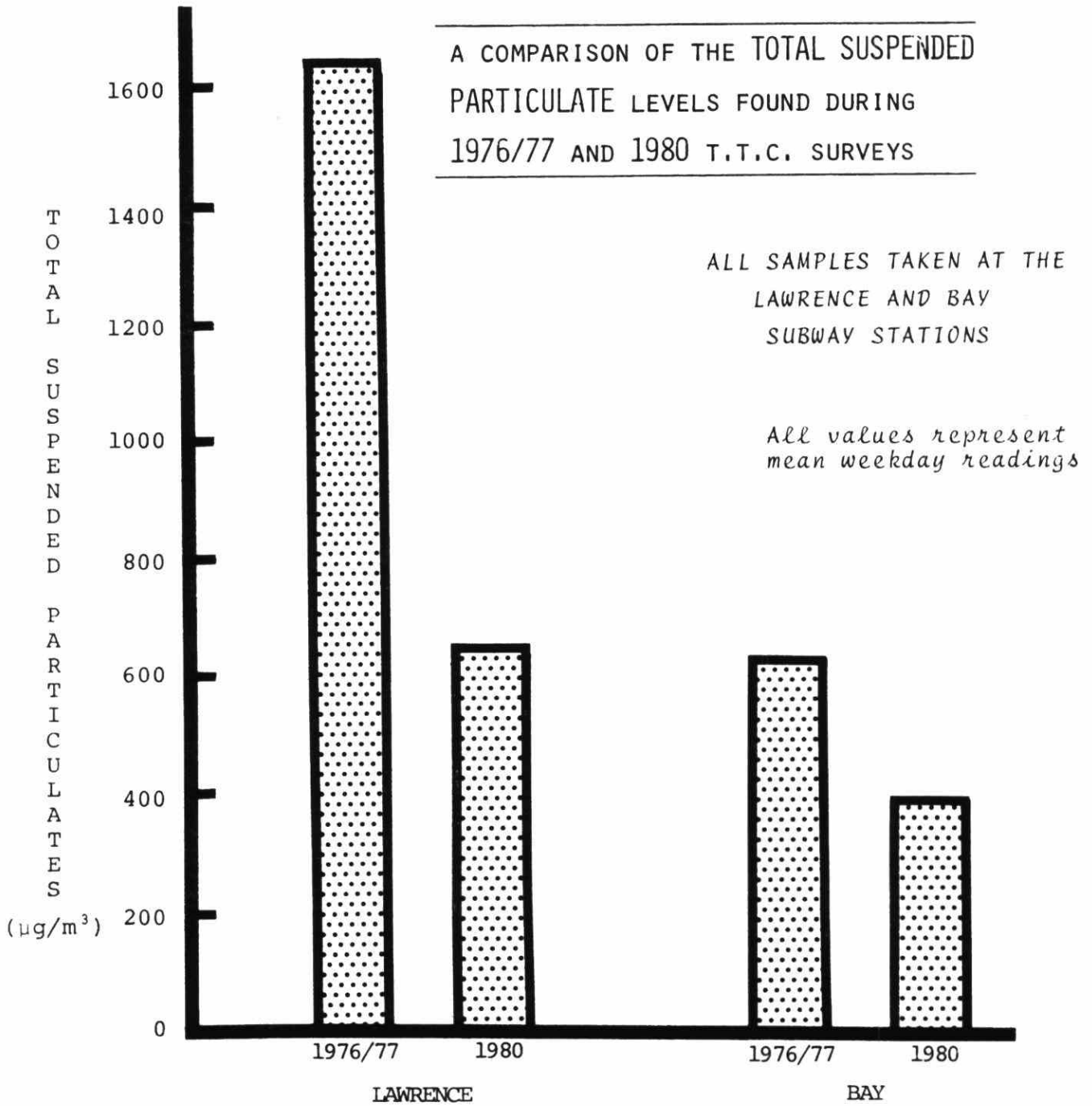

A COMPARISON OF THE TOTAL SUSPENDED PARTICULATE LEVELS FOUND DURING 1976/77 AND 1980 T.T.C. SURVEYS
ALL SAMPLES TAKEN AT THE LAWRENCE AND BAY SUBWAY STATIONS
All values represent mean weekday readings
TOTAL SUSPENDED PARTICULATES (µg/m³)
1600
1400
1200
1000
800
600
400
200
0
1976/77
1980
1976/77
1980
LAWRENCE
BAY
T.T.C. STATION and YEAR of SURVEY

Figure 6.3

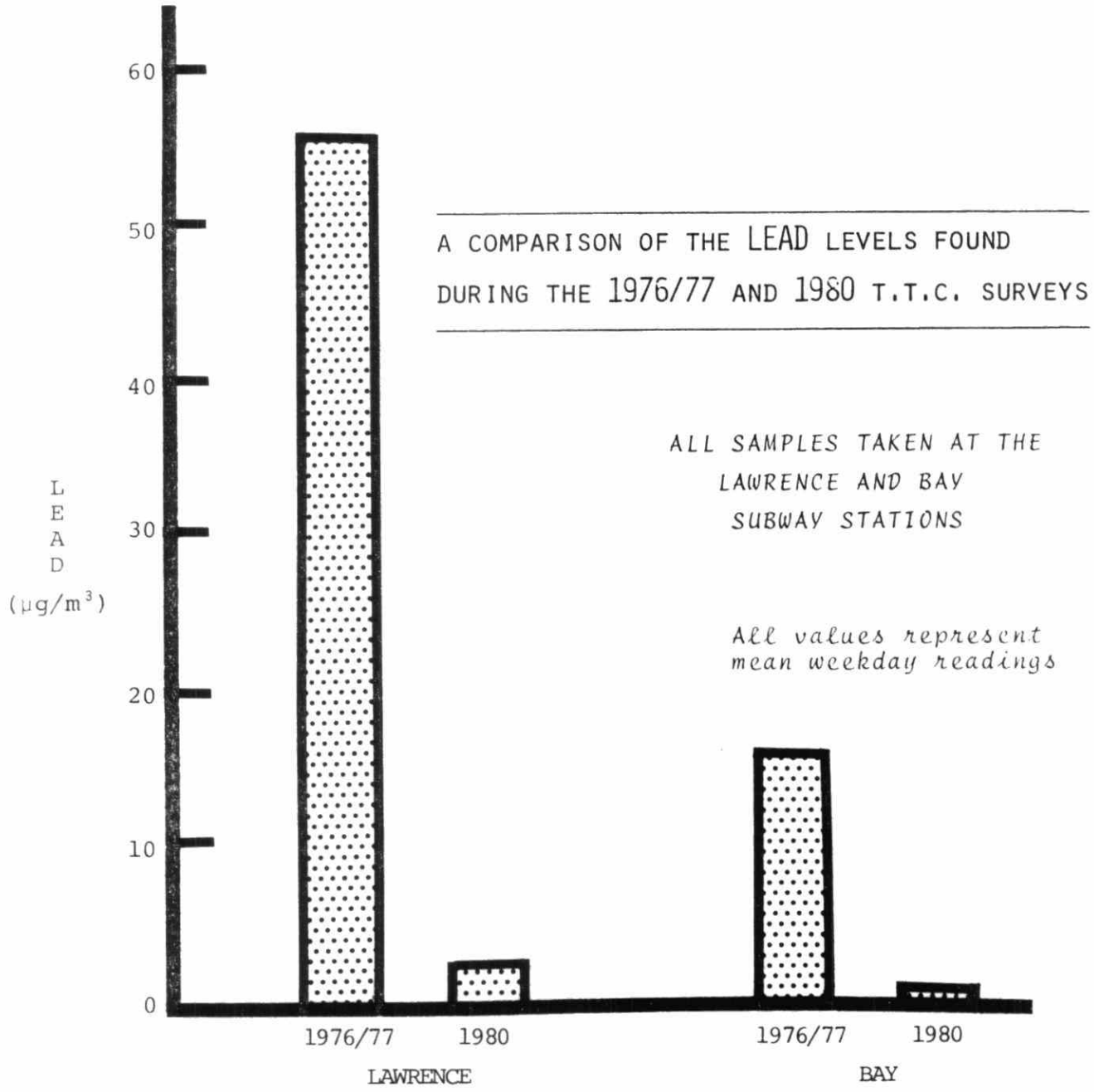

A COMPARISON OF THE LEAD LEVELS FOUND
DURING THE 1976/77 AND 1980 T.T.C. SURVEYS
ALL SAMPLES TAKEN AT THE
LAWRENCE AND BAY
SUBWAY STATIONS
All values represent
mean weekday readings
LEAD
(µg/m³)
60
50
40
30
20
10
0
1976/77
1980
LAWRENCE
1976/77
1980
BAY
T.T.C. STATION and YEAR of SURVEY

Figure 6.4

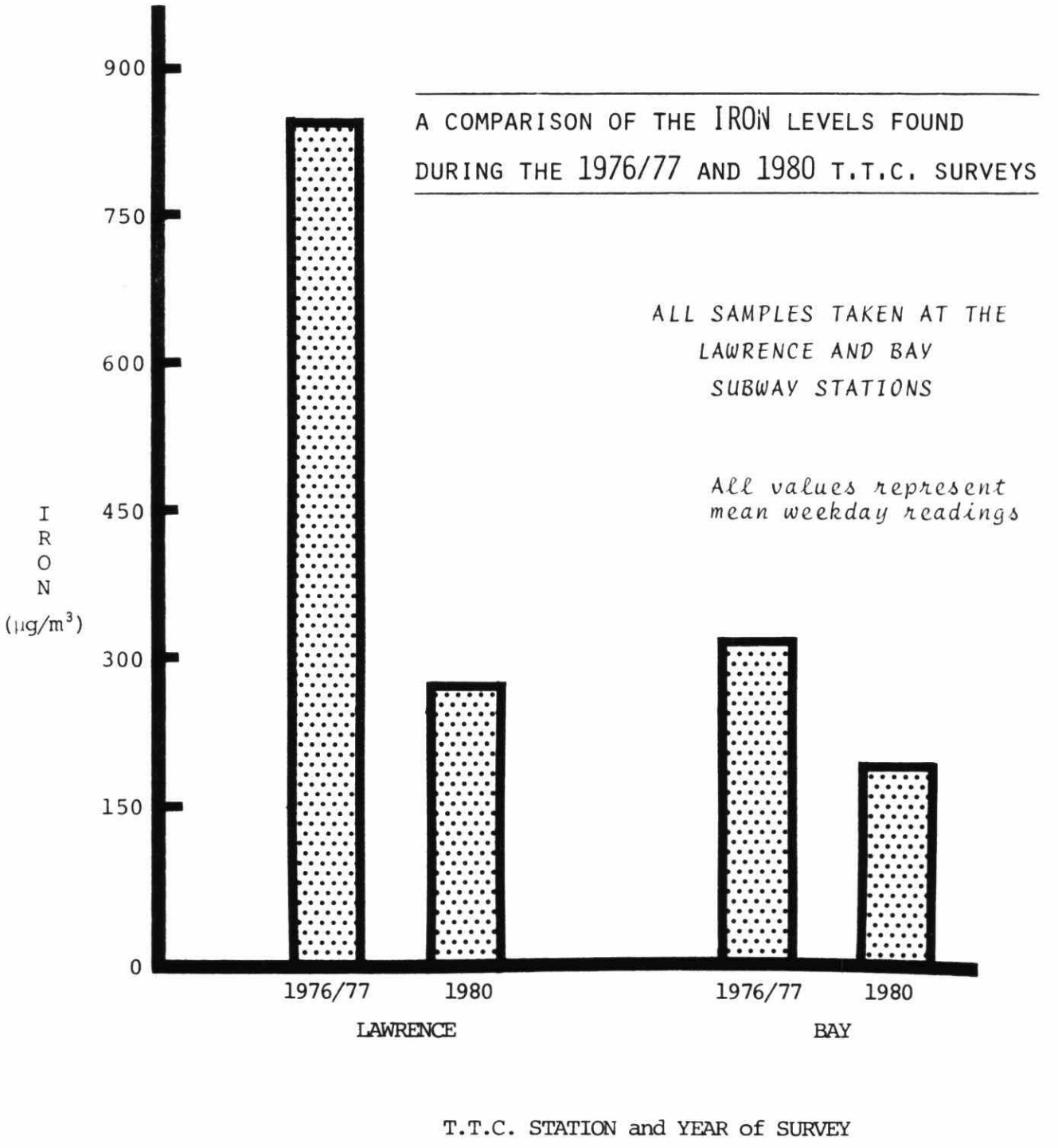

A COMPARISON OF THE IRON LEVELS FOUND
DURING THE 1976/77 AND 1980 T.T.C. SURVEYS
ALL SAMPLES TAKEN AT THE
LAWRENCE AND BAY
SUBWAY STATIONS
All values represent
mean weekday readings
IRON
(µg/m³)
900
750
600
450
300
150
0
1976/77
1980
1976/77
1980
LAWRENCE
BAY
T.T.C. STATION and YEAR of SURVEY

Figure 6.5

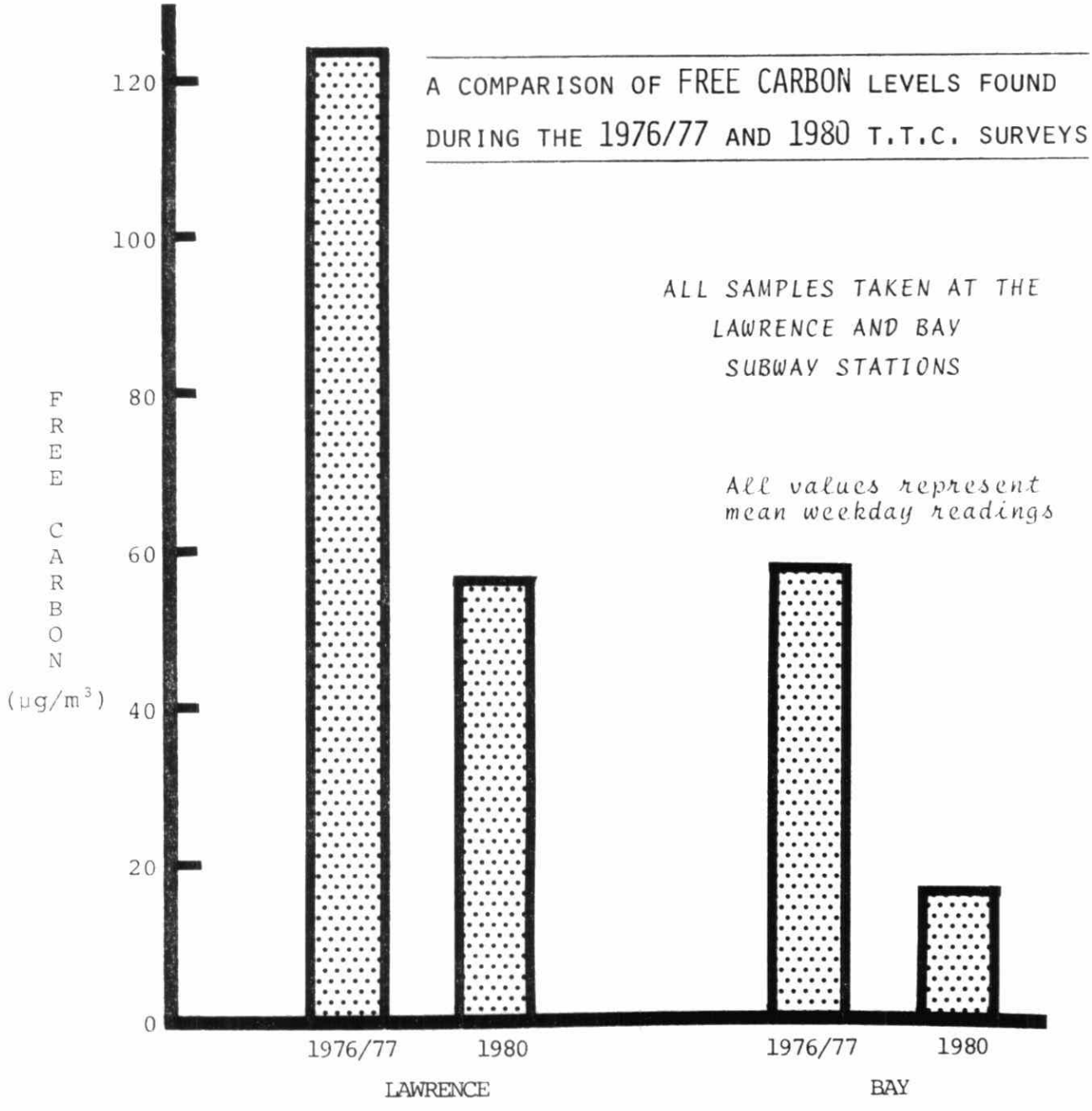

A COMPARISON OF FREE CARBON LEVELS FOUND DURING THE 1976/77 AND 1980 T.T.C. SURVEYS
ALL SAMPLES TAKEN AT THE LAWRENCE AND BAY SUBWAY STATIONS
All values represent mean weekday readings
FREE CARBON (µg/m³)
120
100
80
60
40
20
0
1976/77
1980
1976/77
1980
LAWRENCE
BAY
T.T.C. STATION and YEAR of SURVEY

Figure 6.6

TOTAL SUSPENDED PARTICULATE VERSUS COH FOR 1976/77 AND 1980 AT LAWRENCE STATION

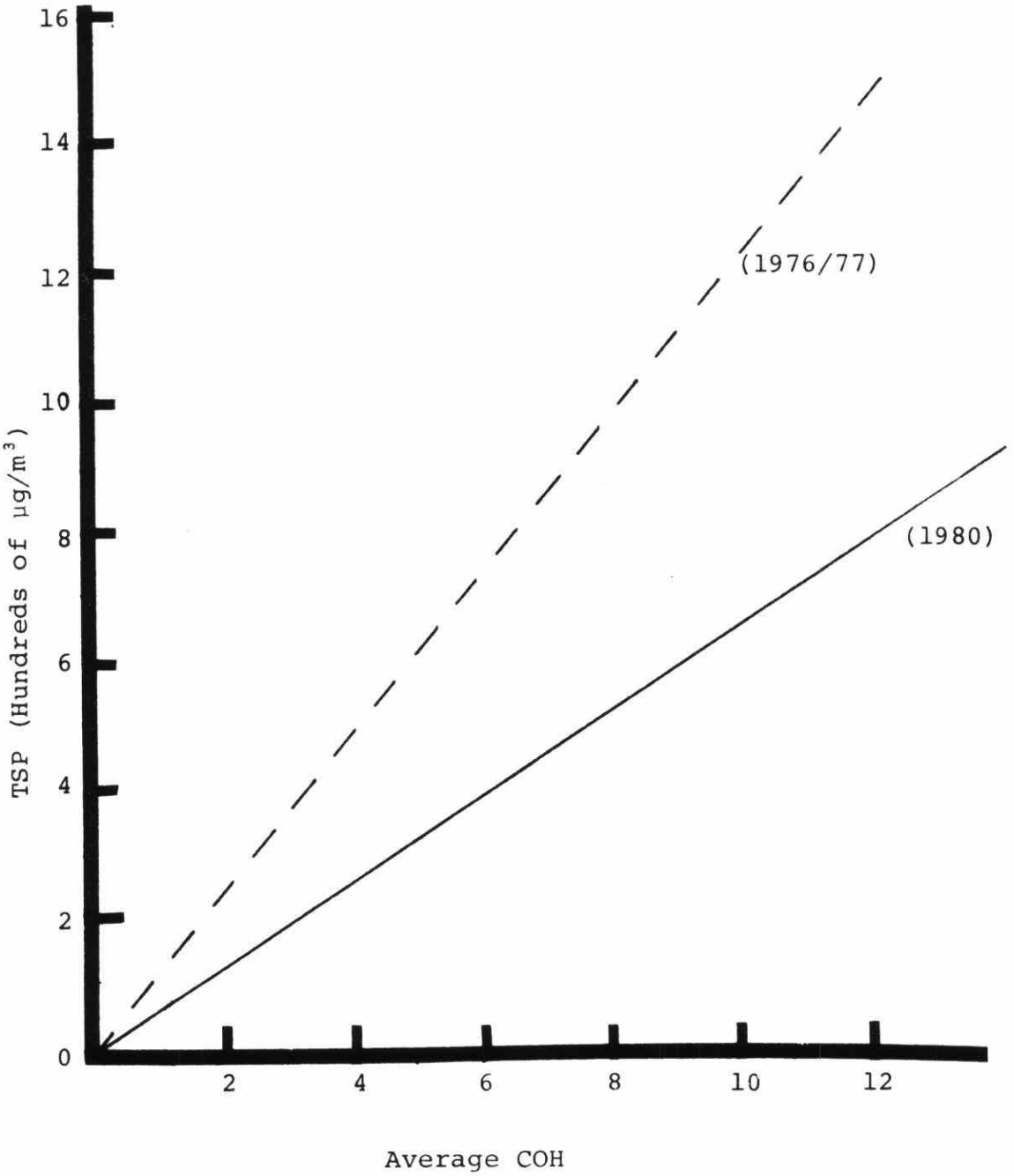
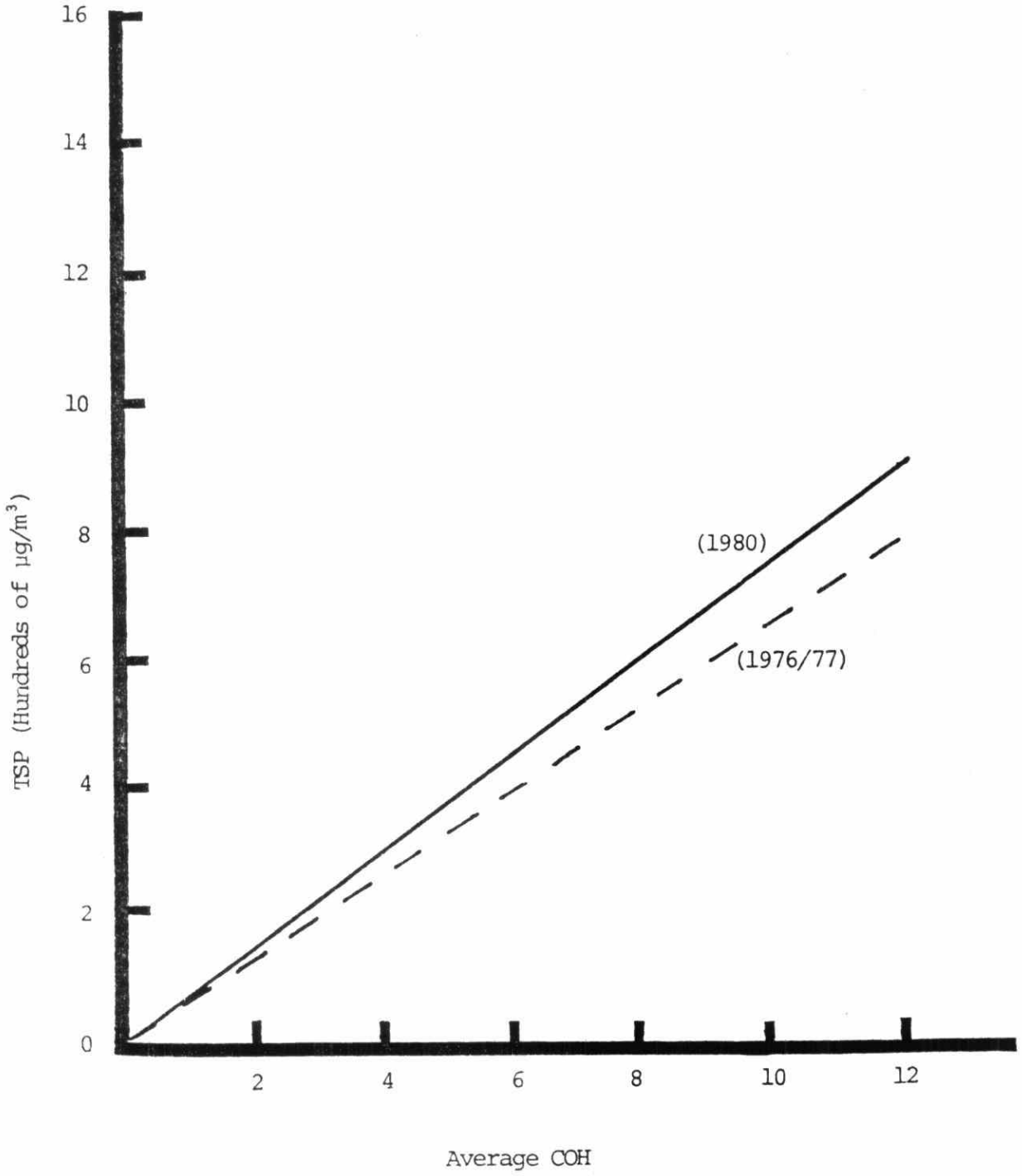


Figure 6.7

TOTAL SUSPENDED PARTICULATE VERSUS COH FOR 1976/77 AND 1980 AT BAY STATION



7.0 Comparison of 1976/77 Findings to 1980 Findings MOL/TTC Occupational Health Survey

7.1 Total Fibre

The sampling results for total fibres in 1980 were all less than the lower limit of statistical reliability of 0.03 fibres/cc of air at both the Lawrence and Pape Stations. These values are lower than those found during the 1976 survey where total fibres results ranged from 0.04 - 0.21 fibres/cc of air at Pape Station and from 0.06 - 0.19 fibres/cc of air at Lawrence Station. In all cases fibre concentrations were well below the 2 fibre/cc Ontario Ministry of Labour guideline for chrysotile asbestos (and the proposed Ontario regulation of 1 fibre/cc).

7.2 Lead (air)

The sampling results for lead in 1980 were all less than the lower limit of detection of 0.01 mg/m^3 of air at both Lawrence and Pape Stations. These values are lower than those found during the 1977 survey where lead results ranged from 0.01 - 0.09 mg/m^3 of air at Lawrence station and from 0.01 to 0.48 mg/m^3 of air at Woodbine Station.*

7.3 Lead (Blood)

For the 1978 survey blood levels ranged from 0.05 mg Pb/L to 0.21 mg Pb/L . The 1980 blood level survey results as presented in Table 5.3 were similar in range and mean value. Neither set of values is significantly different from those of typical urban residents.

7.4 Other Trace Metals (Air)

1980 results were almost all below the lower limit of detection of 0.01 mg/m^3 of manganese in air. No valid comparison can be made, since almost all the 1977 results were also below the lower limit of detection.

For comparison purposes the 1976/77 findings are presented in Table 7.1 - 7.3.

* It is assumed that both Woodbine and Pape Stations have similar characteristics.

Table 7.1

1976 MOL/TTC OCCUPATIONAL SAMPLING TOTAL FIBRE RESULTS

Yonge-University Line, Lawrence Station - October 19, 1976

SAMPLE IDENTIFICATION	OCCUPATION	TOTAL FIBRES GREATER THAN 5 MICROMETERS IN LENGTH PER CC OF AIR
1	Ticket Collector	0.13
2	Cleaner	0.12
3	Trackman	0.09
4	Guard/Driver	0.06
5	Driver/Guard	0.06
6	Passenger	0.13
	Total Samples	6
	Range	0.06-0.13
	Mean	0.10

Yonge-University Line, Lawrence Station - October 20, 1976

SAMPLE IDENTIFICATION	OCCUPATION	TOTAL FIBRES GREATER THAN 5 MICROMETERS IN LENGTH PER CC OF AIR
7	Ticket Collector	0.19
8	Cleaner	0.13
9	Trackman	0.17
10	Guard/Driver	0.07
11	Driver/Guard	0.07
12	Passenger	0.07
	Total Samples	6
	Range	0.07-0.19
	Mean	0.11

The Ontario Ministry of Labour guideline for Chrysotile Asbestos is 2 fibres greater than 5 um in length per cc of air

Table 7.1 Continued

1976 MOL/TTC OCCUPATIONAL SAMPLING TOTAL FIBRE RESULTS

Bloor-Danforth Line, Pape Station- October 19, 1976

SAMPLE IDENTIFICATION	OCCUPATION	TOTAL FIBRES GREATER THAN 5 MICROMETERS IN LENGTH PER CC OF AIR
13	Ticket Collector	0.08
14	Cleaner	0.14
15	Trackman	0.21
16	Guard/Driver	0.06
17	Driver/Guard	0.07
18	Passenger	0.07
	Total Samples	6
	Range	0.06-0.21
	Mean	0.11

Bloor-Danforth Line, Pape Station - October 20, 1976

SAMPLE IDENTIFICATION	OCCUPATION	TOTAL FIBRES GREATER THAN 5 MICROMETERS IN LENGTH PER CC OF AIR
19	Ticket Collector	0.04
20	Cleaner	0.10
21	Trackman	<0.04
22	Guard/Driver	0.06
23	Driver/Guard	<0.04
24	Passenger	0.15
	Total Samples	6
	Range	<0.04-0.15
	Mean	0.07

The Ontario Ministry of Labour guideline for Chrysotile Asbestos is 2 fibres greater than 5 um in length per cc of air

Table 7.2

1977 MOL/TTC OCCUPATIONAL SAMPLING LEAD (AIR) RESULTS

Yonge-University Line, Lawrence Station - September 6, 1977

SAMPLE IDENTIFICATION	OCCUPATION	LEAD CONCENTRATION MG/M^3 OF AIR
1	Ticket Collector	0.03
2	Janitor	0.01
3	Trackman	0.05
4	Driver/Guard	0.05
5	Driver/Guard	0.04
6	Passenger	0.04
	Total Samples	6
	Range	0.01-0.05
	Mean	0.04

Yonge-University Line, Lawrence Station - September 7, 1977

SAMPLE IDENTIFICATION	OCCUPATION	LEAD CONCENTRATION MG/M^3 OF AIR
7	Ticket Collector	0.01
8	Janitor	0.02
9	Trackman	0.04
10	Driver/Guard	0.04
11	Driver/Guard	0.04
12	Passenger	0.04
	Total Samples	6
	Range	0.01-0.04
	Mean	0.03

The threshold limit value for Lead is 0.15 mg/m^3

Table 7.2 Continued

1977 MOL/TTC OCCUPATIONAL SAMPLING LEAD (AIR) RESULTS

Bloor-Danforth Line, Woodbine Station - September 6, 1977

SAMPLE IDENTIFICATION	OCCUPATION	LEAD CONCENTRATION MG/M^3 OF AIR
13	Ticket Collector	< 0.01
14	Janitor	< 0.01
15	Trackman	0.01
16	Driver/Guard	< 0.01
17	Driver/Guard	0.01
18	Passenger	< 0.01
	Total Samples	6
	Range	< 0.01-0.01
	Mean	0.01

Bloor-Danforth Line, Woodbine Station - September 7, 1977

SAMPLE IDENTIFICATION	OCCUPATION	LEAD CONCENTRATION MG/M^3 OF AIR
19	Ticket Collector	0.01
20	Janitor	< 0.01
21	Trackman	0.01
22	Driver/Guard	0.01
23	Driver/Guard	< 0.01
24	Passenger	0.01
25	Ticket Collector	0.02
26	Janitor	0.05
27	Trackman	0.48
	Total Samples	8
	Range	< 0.01-0.48
	Mean	0.10

The threshold limit value for Lead is 0.15 mg/m^3

Table 7.3

1977 MOL/TTC OCCUPATIONAL SAMPLING MANGANESE (AIR) RESULTS

Yonge-University Line, Lawrence Station - September 6, 1977

SAMPLE IDENTIFICATION	OCCUPATION	MANGANESE CONCENTRATION MG/M^3 OF AIR
1	Ticket Collector	< 0.01
2	Janitor	< 0.01
3	Trackman	< 0.01
4	Driver/Guard	< 0.01
5	Driver/Guard	< 0.01
6	Passenger	< 0.01
	Total Samples	6
	Range	< 0.01
	Mean	< 0.01

Yonge-University Line, Lawrence Station - September 7, 1977

SAMPLE IDENTIFICATION	OCCUPATION	MANGANESE CONCENTRATION MG/M^3 OF AIR
7	Ticket Collector	<0.01
8	Janitor	< 0.01
9	Trackman	< 0.01
10	Driver/Guard	< 0.01
11	Driver/Guard	<0.01
12	Passenger	< 0.01
	Total Samples	6
	Range	< 0.01
	Mean	< 0.01

The threshold limit value for Manganese is 5 mg/m^3

Table 7.3 Continued

1977 MOL/TTC OCCUPATIONAL SAMPLING MANGANESE (AIR) RESULTS

Bloor-Danforth Line, Woodbine Station - September 6, 1977

SAMPLE IDENTIFICATION	OCCUPATION	MANGANESE CONCENTRATION MG/M^3 OF AIR
13	Ticket Collector	< 0.01
14	Janitor	< 0.01
15	Trackman	< 0.01
16	Driver/Guard	< 0.01
17	Driver/Guard	< 0.01
18	Passenger	< 0.01
	Total Samples	6
	Range	< 0.01
	Mean	< 0.01

Bloor-Danforth Line, Woodbine Station - September 7, 1977

SAMPLE IDENTIFICATION	OCCUPATION	MANGANESE CONCENTRATION MG/M^3 OF AIR
19	Ticket Collector	< 0.01
20	Janitor	< 0.01
21	Trackman	< 0.01
22	Driver/Guard	< 0.01
23	Driver/Guard	< 0.01
24	Passenger	< 0.01
25	Ticket Collector	< 0.01
26	Janitor	< 0.01
27	Trackman	0.05
	Total Samples	8
	Range	< 0.01-0.05
	Mean	0.02

The threshold limit value for Manganese is 5 mg/m^3

8.0 T.T.C. Subway Operation 1976 - 1980 Comparison

A number of changes have been implemented since the initial 1976 survey. They are:

(1) Expansion of the system by the completion of the Spadina extension.

(2) Conversion of all brake shoe mountings on the 134 'G' cars to accommodate the Cobra W-392 shoe.

(3) The proportion of 'H' cars on the Yonge-University-Spadina line has increased from about 30% to approximately 50%.

The above changes have had the effect of reducing TSP levels by 60% and Pb levels by 95% (based on Lawrence station) for the Yonge-University-Spadina Line. This is in excellent agreement with the predictions of a 57% reduction in TSP and a 90% reduction in lead as calculated in the original report.

Future Changes

Presently the T.T.C. is investigating the wear properties of the Abex Tiger brake shoe. As shown in Table 8.1 this shoe has a lead content of 0.02% by weight - a 50% reduction over the Cobra shoe, and contains no asbestos, as compared to 11.4% by weight for the Cobra shoe. Wear rate tests show that the Tiger wears at a somewhat higher rate, 24,140 km/shoe as compared to 37,000 km/shoe for the Cobra shoe. It is anticipated that the replacement of the 'Cobra' shoe by the 'Tiger' shoe on the 'G' cars should be completed in 1981. This should further lower asbestos and lead levels. The Abex shoe also tends to squeal much less than the Cobra shoe.

Table 8.1

BRAKE SHOE DATA

1. Characteristics:

Shoe Type	Specific Weight gm/cm^3	Asbestos Content by Wt (%)	Iron Content by Wt (%)	Lead Content by Wt (%)
Griffin "Anchor"	2.42	9.5	19.3-20.2	8.5
Wabco "Cobra" W-392	1.68	11.4	10.6	0.03
Abex "Tiger"	2.20	0	11.7-20	0.02

2. Brake Shoe Wear:

2.1 Gloucester cars with Abex "Tiger" brake shoes. (Friction brake only).

No. of cars	- 134
No. of shoes per car	- 16
Average car km per year (1979)	- 69,200 km
Average life per brake shoe	- 24,000 km
Average volume abraded per brake shoe	- 721 cm^3
Rates of abrasion	- .0300 cm^3/shoe km
	- .48 cm^3/car km
	- 1.056 gm/car km
	- 73 kg/car year
	- 9,782 kg/fleet year

2.2 M & H Subway Cars with Wabco "Cobra" W-392 brake shoes. (Electrodynamic brake + friction).

No. of cars	- 494
No. of shoes per car	- 8
Average car km per year (1979)	- 113,700 km
Average life per bake shoe	- 112,650 km
Average volume abraded per brake shoe	- 688 cm^3
Rates of abrasion	- .0061 cm^3/shoe km
	- .0488 cm^3/car km
	- .082 gm/car km
	- 9.318 kg/car year
	- 3670 kg/fleet year

* Abex "Tiger" test shoe only on about 20 'G' cars, other 'G' cars fitted with "Cobra" W-392 shoes.

Table 8.1 Continued

3. Wear Rates of Brake Shoes (50 mm thick):

From tests on Subway Cars, updated to September 1980.

Car Type	Brake Shoe Type	Brake Shoe Per Car	km/shoe
G	Anchor	16	25,750
G	Cobra W-392	16	37,000
G	Tiger	16	24,140
M&H	Cobra W-392	8	112,650
M&H	Anchor	8	86,900